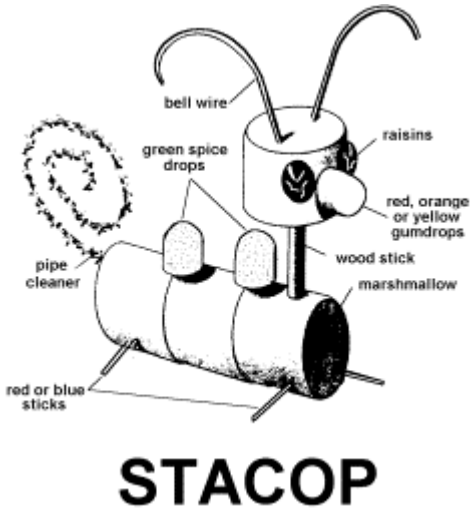
Genetics With STACOPS

Overview

Using their knowledge of genetics and heredity, students will participate in activities involving the chromosomes of a created animal called a STACOP. Based on the genetic information of a "mated" pair of STACOPs, students will make inferences about the genetic combinations the STACOPs' offspring might inherit. Various baby STACOPs will then be created using several of the many possible combinations of the STACOP genetic code. Students will be introduced to the use of probability and Punnett squares to predict the outcome of genetic crosses. The STACOPs activity is divided into four parts:



Part 1 - *Trait Identification* during which students examine STACOPs to assess what they already know about heredity and identify the traits that can vary.

Part 2 - *Forming Gametes and Fertilization* during which students form and combine STACOP gametes using paper strip chromosomes.

Part 3 - *Development of the Baby STACOPs* during which students assemble babies using the STACOP genetic code.

Part 4 - *Predicting Outcomes* during which students use invented methods as well as Punnett squares to predict possible traits of STACOP offspring

Suggested Use

The STACOPs activity is linked to another Science/Math/Technology Weekends activity, *Gene Schemes,* (available as a PDF downloadable file on the Science/ Math/ Technology Weekends website). Both "Genetics with STACOPs" and "Gene Schemes" are stand-alone activities. However, using both activities in conjunction with each other will extend your students' knowledge of these topics.

You may wish to administer the New York Intermediate Level Science Examination (ILSE) Test Sampler to determine your students' needs. The understandings this activity presents are correlated with the New York State Education ILSE Test Sampler # 3, 5, 6, 25, 26, 27, 33, 34.

Approximate Time

You should allow four 45-minute sessions in order for students to be able to complete all of the activities. Keep in mind that timing may also vary depending upon the students' experiences with cooperative learning and students' needs and interests.

Genetics With STACOPS

Content Background

Students will need to understand that most types of plants and animals, including humans, need two parents, one male and one female, to reproduce. Each parent produces reproductive cells that are called *gametes*. Each of the *gametes* contains half of the parent's heredity material, or *chromosomes*. Each gamete carries one-half of the genetic information from each parent. So, for example, a human body cell, such as a skin cell, has 23 pairs of chromosomes or a total of 46 chromosomes. However, a human *gamete* (*e.g.*, a sperm or egg) contains only 23 chromosomes because it has only one chromosome from each pair.

Gametes are formed from special cells in a process called *meiosis*. When a male gamete (sperm) unites with a female gamete (egg), the egg becomes fertilized. The fertilized egg contains genetic information from each parent. This fertilized egg cell or *zygote* divides by mitosis forming two new cells which, in turn, divide. As the cells continue to divide, the organism develops and cells begin to specialize to form parts with different functions and characteristics.

Genes are the factors that control the expression of traits. There are two copies of each gene, one from the father and one from the mother. These genes can take different forms, which are called alleles. For example, there is a gene for the color of a pea plant. It has two *alleles*-one for green and one for yellow. In pea plants, green is dominant and yellow is recessive.

A *dominant* allele is one whose trait always shows up, even when only one of the two alleles is the dominant form. A dominant allele is indicated as a capital letter (A). A *recessive* allele is one that is hidden when the other copy of the gene contains the dominant allele. Only if neither of the two genes carries the dominant allele will the recessive trait (*e.g.*, the color yellow in pea plants) show up in the actual plant (*phenotype*).

Some traits do not follow the dominant-recessive pattern. When an organism has two different alleles for a gene that does not follow that pattern, it exhibits a trait that is a blend of the traits represented by the two alleles. For example, the gene for the color of roses has one allele for red and one for white. When both are present, neither dominates, and the resulting color of the rose is pink.

The probability of certain traits being expressed can be determined by using Punnett squares. A Punnett square is a chart that shows all the possible combinations of alleles that can result from a genetic cross (see *Handout 7: Punnett Squares*).

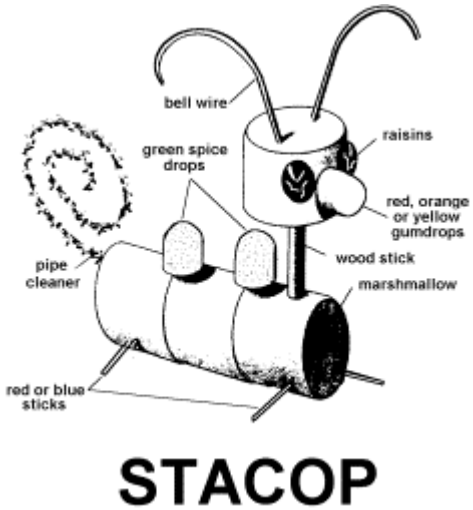
The study of genetics and heredity should include activities with organisms that can be easily bred. The ideal organism for such a study should have the following characteristics:

- The organism should require little care.
- The organism should be inexpensive and easy to obtain.
- The organism should have a limited number of traits on a limited number of chromosomes.
- The chromosomes should be very large and easy to see.
- The organism will be able to produce as many generations as needed.

Traditionally, organisms such as fruitflies or, more recently, fast plants have been used. As an alternative, you can use STACOPs. They are student-made organisms assembled from

commonly available, inexpensive materials. STACOPs are based on Reebops as described in "Marshmallow Meiosis" by P.Soderberg in *The Science Teacher* 59(8) 28-31, 1992.

Basic STACOP Information



Genetically, STACOPs contain 14 chromosomes (consisting of 7 pairs). Each parental set consists of 7 pairs of chromosomes, each pair having a different length and containing a single gene as shown on the Chromosome Template handout.

STACOP Genetic Code Chart

Body Part	Variation/Trait	Phenotypes	Genotypes
Antennae	Number	Two one none	AA Aa aa
Legs	Color	blue red	LL or Ll ll
Eyes	Number	Two one	EE or Ee ee
Humps	Number	One two three	HH Hh hh
Tail	Shape	curly straight	TT or Tt tt
Nose	Color	red orange yellow	NN Nn nn
Body segments	Number	three two	SS or Ss ss

STACOPs can have one, two or no antennae; red or blue legs; one or two eyes and one, two or three humps. Their tails may be straight or curly; their noses may be red, orange or yellow and they may have two or three body segments. These traits, as well as STACOP genotypes and phenotypes are listed in the STACOP Genetic Code Chart.

Vocabulary

blended inheritance	cell	chromosome
dominant	gamete	gene
genetic code	heredity	genotype
meiosis	phenotype	Punnett square
recessive	trait	

Additional Information

Each first generation parent that you will construct is heterozygous for all seven traits (*e.g.*, both the mother and father are Aa for antennae, Ll for legs, and so on.) In mating, each parent will contribute to the offspring one of 128 (two to the seventh power) possible combinations of genes, and the offspring can end up with any of 2,187 (three to the seventh power) possible combinations of genes. Because some genotypes produce identical phenotypes, there are only 512 possible phenotypes.

Genetics With STACOPS

New York State Core Curriculum Major Understandings for Grades 5 to 8

These are the New York State Core Curriculum Major Understandings for Grades 5 to 8 that are supported by this activity.

2.1a Heredity information is contained in genes. Genes are composed of DNA that makes up the chromosomes of cells.

2.1b Each gene carries a single unit of information. A single inherited trait of an individual can be determined by one pair or many pairs of genes. A human cell contains thousands of different genes.

2.1e In sexual reproduction typically half of the genes come from each parent. Sexually produced offspring are not identical to either parent.

2.2b Some genes are dominant and some are recessive. Some traits are inherited by mechanisms other than dominance and recessiveness.

2.2c The probability of traits being expressed can be determined using models of genetic inheritance. Some models of prediction are pedigree charts and Punnett squares.

(The understandings this activity presents are correlated with The State Education ILSE Test Sampler # 3, 5, 6, 25, 26, 27, 33, and 34.)

Genetics With STACOPS

New York City edition of the New Standards ™ Performance Standards for Science - Middle School

These are the New York City edition of the *New Standards™ Performance Standards* for Middle School Science that are supported by this activity.

The student demonstrates conceptual understanding of (S2b) reproduction and heredity, such as sexual and asexual reproduction: and the role of genes and environment on trait expression by using these concepts accurately to explain observations and make predictions and by representing the concepts in multiple ways (through words, diagrams, graphs, or charts, as appropriate).

This activity can be adapted to address standards listed in the New York City edition of the New Standards™ Performance Standards for Science-High School and the *New York State Core Curriculum for The Living Environment.*

Genetics With STACOPS

Materials

The following is a list of all the materials that will be required for all four parts of the STACOPs activity. Each part will have a list of materials that are specific to it.

For each class you will need:
- Chart paper

For each student you will need:
- Copies of *Handouts 1 to 7*

For each group of 2 to 4 students you will need:
- Two sets of chromosomes in two envelopes: one envelope with STACOP Mother's chromosomes; one with STACOP Father's chromosomes. See *Chromosome Templates*.

You will need to make at least four STACOPs and each student group will make at least one.
The materials needed to make 6 STACOPs are:
- Twelve 3 cm pieces of bell wire
- Twelve green spice or gum drops
- Six each of red, orange and yellow spice or gum drops
- Six 4 cm pieces of pipe cleaner
- Twelve raisins
- Twenty-four 4 cm red sticks (coffee stir sticks or toothpicks)
- Twenty-four 4 cm blue sticks (coffee stir sticks or toothpicks)
- Eighteen large marshmallows
- Six wood coffee stir sticks (for STACOP neck)
- Uncolored large and small toothpicks (for joining body parts)

Texts
Having related readings available will augment your students' learning about genetics and heredity. These readings can come from your school's textbooks and from recommended sites on the Internet (see Technology Connections). Here are additional recommended texts:

> *Cells are Us*, Lerner Publishing, Fran Balkwill, M.D. Cells and Things series. http://www.lernerbooks.com
>
> *Amazing Schemes within Genes*, Lerner Publishing, Fran Balkwill, M.D. Cells and Things series. http://www.lernerbooks.com

Genetics With STACOPS

Getting Ready

1. Buy marshmallows and take them out of the bag and allow them to harden several days before using. (Soft marshmallows will be too floppy to work with.) When assembling STACOPs, body parts may be connected with large or small toothpicks.

2. Assemble a pair of "parent" STACOPs according to the following table:

STACOP Parent Genetic Information Chart	
Body Part	**Phenotype**
Antenna	1 bell wire
Legs	4 blue sticks
Eyes	2 raisins
Humps	2 green spice drops
Tail	1 curly pipe cleaner
Nose	1 orange spice drop
Body Segments	3 marshmallows

These identical parents are the STACOPs that will “mate.”

3. Using the following table, assemble two additional STACOPs in order to show possible variations in STACOP traits. With these two STACOPs, in addition to the parents made previously, you will have examples of all of the STACOP traits.

STACOP Variations 1 and 2 – Genetic Information Chart		
Body Part	**Variation 1**	**Variation 2**
Antenna	2 bell wire	No bell wire
Legs	Red sticks	Blue sticks
Eyes	1 raisin	2 raisins
Humps	1 green spice drop	3 green spice drops
Tail	Straight pipe cleaner	Curly pipe cleaner
Nose	Red spice drop	Yellow spice drop
Body Segments	2 marshmallows	2 marshmallows

4. You may wish to build additional STACOPs so that they can be examined by each student group.

5. Copy the *Chromosome Template (Mother)* and the *Chromosome Template (Father)* so that each pair of students has one of each. Cut apart chromosomes on lines and place in appropriately labeled envelope - either *Mother* cell or *Father* cell. Notice that Father’s chromosomes appear on a gray background on your computer screen. This is done to help you and the students differentiate between both sets because they are identical in all other ways. Your printer may not print gray, however. If it doesn't, you will have to photocoy the templates

using two different colors of paper (*i.e.*, one color for Mother chromosomes, another for Father chromosomes) to help students tell them apart.

6. Copy *Handouts 1* through *7*.

7. Place materials appropriate to lesson in containers or trays for each group.

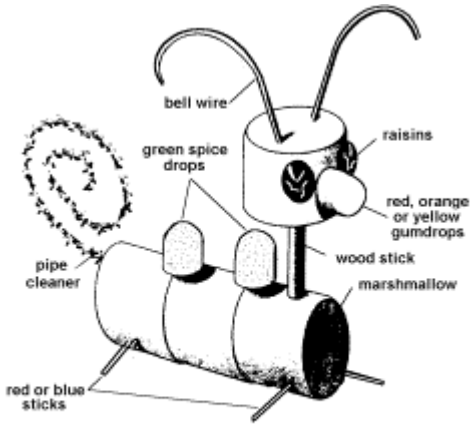
Note: Handouts are provided to give students directions as well as a place to record responses, questions and results. In order to encourage students to write more in-depth responses, you may wish to provide journals.

Genetics With STACOPS

Handout 1: STACOP Genetic Code

Name: _____ Class: _____ Group:_____Date:_____

Vocabulary		
heredity	genes	genotype
trait	chromosomes	phenotype
dominant	recessive	blended inheritance



STACOP

Introduction

STACOPs are models that you will use to learn more about *heredity* – the study of how parents pass on their *traits* or characteristics to their offspring. As you work with STACOPs, you will learn more about *chromosomes*, which are the cell parts that contain the "recipe" for making an organism. And you will learn about *genes*, which are found on the chromosomes, and the role they play in heredity.

STACOPs are different from living things in many ways. (They are, after all, made of marshmallows.) One important difference is that on each STACOP chromosome, there is only one gene. Living things, however, can have thousands of genes on a single chromosome. STACOPs and real-life plants and animals *are* alike in one important way. They both have *dominant* and *recessive* genes…

Dominant and Recessive Genes

Did you ever wonder why a parent's trait doesn't show up in his or her offspring? And why this trait might show up in a second or even later generation? The reason is because some traits are *recessive*. In order to show up, both parents have to pass on the recessive gene. Otherwise the *dominant* gene will be expressed. For example, two Labrador dog parents with dominant black fur won't have puppies with brown fur unless both of them have the recessive gene for brown fur. And, even if both parents have the recessive gene, a puppy won't have brown fur unless it gets two copies of the brown fur gene, one from each parent.

With STACOPs blue leg color is dominant (LL). That means if a STACOP has only one recessive gene for red legs, (Ll) it will have blue legs. But if a STACOP inherits a red leg gene from both parents (ll), it will have red legs.

STACOP Genetic Code			
Body Part	**Variation/Trait**	**Phenotypes**	**Genotypes**
Antennae	Number	Two One None	AA Aa aa
Legs	Color	Blue Red	LL or Ll ll
Eyes	Number	Two One	EE or Ee ee
Humps	Number	One Two Three	HH Hh hh
Tail	Shape	Curly Straight	TT or Tt tt
Nose	Color	Red Orange Yellow	NN Nn nn
Body segments	Number	Three Two	SS or Ss ss

Check out nose color, however. There is blended inheritance going on there. Two N forms of the gene (NN) will mean a red nose. Two n forms of the gene (nn) will lead to a yellow nose. One of each (Nn) will lead to a blend of both colors, or an orange nose.

Discuss in your group why STACOPs' body traits vary. Then write.

_____

_____

_____

_____

_____

_____

_____

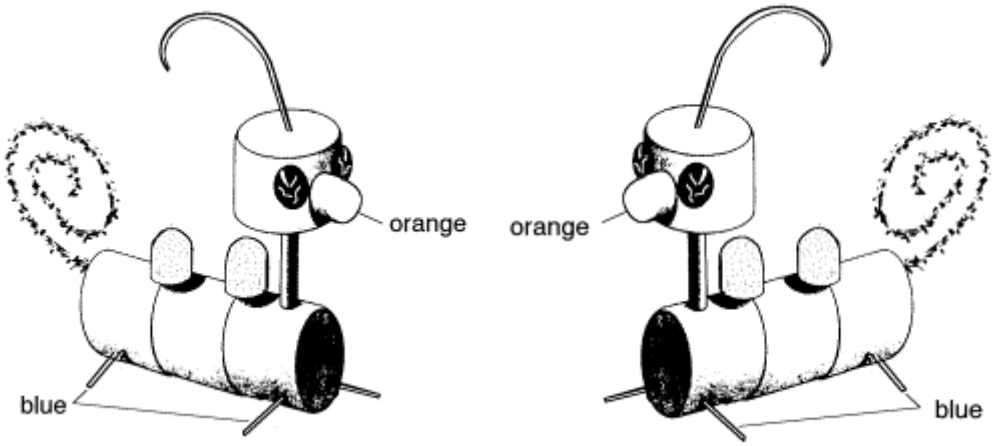
Genetics With STACOPS

Handout 2: Genotype and Phenotype

Name: _____ Class: _____ Group:_____Date:_____

Genotype and Phenotype

Remember those two Labrador dogs with black fur? Suppose you wanted to know if together they could have brown puppies? You couldn't tell by looking at them. What they are actually like is called their **phenotype**. But if you could read their **genotype**—the genetic code that they inherited from their parents—you could tell if they had the recessive gene for brown fur. Even without reading the genotype, we can make guesses about two dogs' offspring.



Mother STACOP Father STACOP

But that's enough about dogs. Let's get back to STACOPs. You are going to make some educated guesses or predictions about the phenotypes of Mother and Father STACOPs' offspring. Since you can't see Mother's and Father's genotypes, you will have to base your predictions on Mother's and Father's actual appearances or phenotypes.

Could these parents who appear identical have different genotypes? Explain why or why not:

_____

_____

_____

_____

1. Use your observations and the STACOP genetic code from Handout 1 to complete the phenotype and possible genotypes. You will complete the actual genotype columns later.

Body Part	Variation/Trait	Phenotype	Possible Genotypes For Parent Phenotype	Actual Genotype of	
				Mother	Father
Antennae	Number				
Legs	Color	*Blue*	*LL, Ll*		
Eyes	Number				
Humps	Number				
Tail	Shape				
Nose	Color				
Body segments	Number				

Check Your Predictions

2. Ask your teacher for a STACOP Father and Mother “cell”. Look through the “cell” and find the set of genes. Do these parents each have a genotype that matches one of the possible genotypes that you came up with for each trait?

   Check: < > yes (or) < > no

3. Enter the actual genotype of the STACOP parents into the last column in the chart.

Write the total number of genes that each STACOP has. _____
Write how many traits your STACOP has. _____

Explain why there is a different number of genes and traits.

_____

_____

_____

Explain where these genes came from.

_____

_____

_____

Genetics With STACOPS

Handout 3: STACOP Reproduction-Part I

Name: _____ Class: _____ Group:____ Date:_____

STACOPs reproduce sexually to produce new offspring. They need both a male and a female parent. Just like other creatures that reproduce sexually, to produce a baby, STACOPs need:

- A cell from the father that produces a sperm cell
- A cell from the mother that produces an egg cell

You will need a Father "cell" envelope and a Mother "cell" envelope.

STACOP Genetic Code			
Body Part	**Variation/Trait**	**Phenotypes**	**Genotypes**
Antennae	Number	Two One None	AA Aa aa
Legs	Color	Blue Red	LL or Ll ll
Eyes	Number	Two One	EE or Ee ee
Humps	Number	One Two Three	HH Hh hh
Tail	Shape	Curly Straight	TT or Tt tt
Nose	Color	Red Orange Yellow	NN Nn nn
Body segments	Number	Three Two	SS or Ss ss

1. **Divide your group into two. One half of your group will be the Mother and the other half will be the Father. The Father should take the "Father" cell envelope. The Mother should take the "Mother" cell envelope.**

   How many traits does a STACOP have? _____
   How many genes are in the mother cell? _____
   How many genes are in the father cell? _____
   Why do you think there are a different number of genes and traits?
   _____
   _____

_____
_____
How many of these genes will be passed on by each parent to the baby STACOP? _____

How many chromosomes will a baby STACOP cell have? _____

2. **Discuss what must happen so that your baby will have all the genes that it needs. Write the steps:**

_____
_____
_____
_____
_____
_____
_____
_____

Genetics With STACOPS

Handout 4: STACOP Reproduction-Part II

Name: _____ Class: _____ Group:____ Date:_____

Work with your group to answer these questions. You may use reference books or other sources to help you.

1. Arrange your Father or Mother chromosomes (genes) in pairs by trait, with the code letters facing down. So, for example, both leg genes will be placed side by side. Randomly choose one chromosome (gene) for each trait. You should have half the number of your Father or Mother chromosomes (genes).
   If you did this again, would you end up with the same combination of genes? Why or why not? (Try it out if you are not sure.)
   _____
   Suppose you repeated this 50 times. What would be the probability of your selecting the same two genes for each trait? _____
   Do you remember the name of the process that produces cells that have half the number of chromosomes of the parent? It is meiosis.
   Write the name of the kind of cells that contain only half the number of a father's genes (chromosomes). _____
   Write the name of the kind of cells that contain only half the number of a mother's genes (chromosomes). _____

2. Now, combine your chromosomes (genes) with your partner's.
   What is the name of the process when parents' genes are combined? _____
   What does this process produce? _____

3. Place the chromosomes that you didn't use in the "Mother" and "Father" cell envelopes. Place the chromosomes that you combined with your partner in the blank envelope. Label it with the term you used to answer question 5.
   On the back of this sheet, write what you know about how STACOP babies receive their genes from their parents.

Genetics With STACOPS

Handout 5: Baby STACOPs

Name: _____ Class: _____ Group:____ Date:_____

Vocabulary

meiosis	gametes	fertilize
egg cell	sperm cell	

In the previous part of this activity, you produced two gametes--the egg cell and the sperm cell. You then fertilized the egg cell by joining the genetic material from the father with the genetic material of the mother. You have a fertilized egg. Now it is time for your baby to be "born".

What do you need to do to find out what your baby will look like?
_____

1. Examine your baby's chromosomes and fill in its genotype in the table below. Using the STACOP Genetic Code, fill in your baby's phenotype.

Your STACOP Baby			
Body Part	**Variation/Trait**	**Genotype**	**Phenotype**
Antennae	Number		
Legs	Color		
Eyes	Number		
Humps	Number		
Tail	Shape		
Nose	Color		
Body Segments	Number		

2. Working with your partner, follow the phenotype you've made and put together a baby STACOP. Place it in the nursery area.
3. Compare your baby with the other babies in the nursery. Write why you think that there is such diversity.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

STACOP GENETIC CODE			
Body Part	**Variation/Trait**	**Phenotypes**	**Genotypes**
Antennae	Number	Two One One	AA Aa aa
Legs	Color	Blue Red	LL or Ll ll
Eyes	Number	Two One	EE or Ee ee
Humps	Number	One Two Three	HH Hh hh
Tail	Shape	Curly Straight	TT or Tt tt
Nose	Color	Red Orange Yellow	NN Nn nn
Body segments	Number	Three Two	SS or Ss ss

Genetics With STACOPS

Handout 6: Making Predictions

Name: _____ Class: _____ Group:____ Date:_____

Consider your Mother and Father STACOPs' leg color genes. Can you predict the color of the legs of their babies?

STACOP GENETIC CODE			
Body Part	**Variation/Trait**	**Phenotypes**	**Genotypes**
Antennae	Number	Two One One	AA Aa aa
Legs	Color	Blue Red	LL or Ll ll
Eyes	Number	Two One	EE or Ee ee
Humps	Number	One Two Three	HH Hh hh
Tail	Shape	Curly Straight	TT or Tt tt
Nose	Color	Red Orange Yellow	NN Nn nn
Body segments	Number	Three Two	SS or Ss ss

1. Divide your group into two. Ask your teacher for the Mother and Father chromosomes in the "cell" envelopes.
   One half of your group will be the mother and the other half will be the father. The father should take the father genes for leg color, the mother the mother genes for leg color.
   What genes for leg color does the father have? _____ and _____
   What genes for leg color does the mother have? _____ and _____
   When you make a sperm cell, what gene for leg color could the sperm cell have?
   _____
   When you make an egg cell, what gene for leg color could the egg have?
   _____
2. In the chart below, list all the possible combinations of genes, genotype and phenotypes for leg color that a baby could have .

Gene from father	Gene from mother	Genotype of baby	Phenotype

Are there any babies that have exactly the same genes? If so, why are they on different lines in the chart?

_____
_____
_____

This chart is helpful, but is there a shorter, easier way to predict all the possible genotypes of the baby? Can you figure out the probability of having red-legged or blue-legged babies as a ratio? a percent? Write in the space below.

Genetics With STACOPS

Handout 7: Punnett Squares

Name: _____ Class: _____ Group:____ Date:_____

One easy way to show all of the genotypes is to use a Punnett Square. Here is a model filled out for leg color. The phenotype is in ( ).

Ll x Ll	L	l
L	LL (blue)	Ll (blue)
l	Ll (blue)	ll (red)

You can tell that these STACOPs could have blue- or red-leged offspring. There is a 1 out of 4 or 25% chance that an offspring will have red legs. Use the Punnett squares to figure out the probability of these different parents having offspring with curly tails. Add the phenotype as well.

TT x Tt	_____	_____
_____		
_____		

What is the probability of these different parents having offspring with:

Two or three body segments?

Ss x ss	_____	_____
_____		

_____		

One or two eyes?

Ee x Ee _____ _____

_____		
_____		

One, two, or three humps?

HH x hh _____ _____

_____		
_____		

Red, orange, or yellow nose?

NN x Nn _____ _____

_____		
_____		

Challenge
What are all the possible genotypes for the offspring of a father who is Aa and Ll and a mother who is AA and ll? Write your solution on the back (include the phenotypes as well).

Genetics With STACOPS

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STACOPs are based on Reebops as describes in "Marshmallow Meiosis" by P. Soderberg in The Science Teacher 59(8) 28-31,1992.